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Glaude-Smit, S.W.D; van Strien, J.W.; Licht, R.; Bakker, D.J.

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Neuropsychological Intervention in Kindergarten Children with Subtyped Risks of Reading Retardation

Sietsia W. D. Smit-Glaudé
Enkhuizen & Hoorn, The Netherlands

Jan W. van Strien
Erasmus University, Rotterdam

Robert Licht
Dirk J. Bakker
Free University, Amsterdam

Kindergarten children at risk of developing language problems were administered the Florida Kindergarten Screening Battery. A principal components analysis revealed a verbal and a visual-spatial component and subsequent discriminant function analyses a high verbal/low visual-spatial group (LAL: Latent L) and a high visual-spatial/low verbal group (LAP: Latent P). LAL- and LAP-children were considered at risk for developing an L- or P-type of dyslexia, respectively. As is common practice with children suffering from manifest L- or P-dyslexia, the LAL- and LAP-kindergartners received right and left hemisphere stimulation, respectively. The outcomes were compared with those of bilateral hemispheric stimulation and no intervention. Reading tests were administered in primary school Grades 1 and 5/6; teachers' evaluation of reading took place in Grade 5/6. Overall, the LAL- and LAP- groups showed significant backwardness in word and

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text reading, both at early and late primary school. Types of intervention made a difference though: not significantly backward in early word, late word, and late text reading were the LAL-children who had received right hemisphere stimulation. Nonintervened LAP-children did not show significant backwardness in early word reading and late text reading, nor did LAP-children who had received left hemisphere or bilateral stimulation. Early text reading was not affected by any treatment. Teacher's evaluations were in support of these findings.

Key Words: Early intervention, follow-up investigation, hemispheric stimulation, precursors of dyslexia, short- and long-term outcomes, subtypes of latent dyslexia

INTRODUCTION

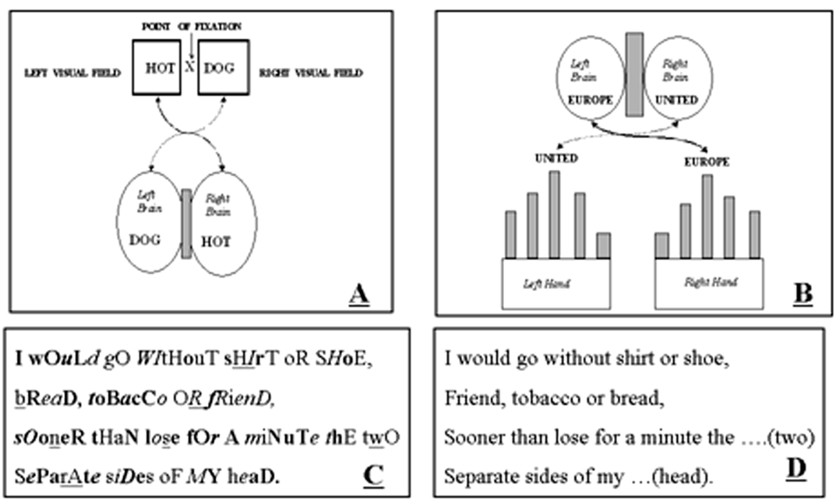
Bakker and associates (Bakker, 1979, 2002; Licht, Bakker, Kok, & Bouma, 1988; Robertson & Bakker, 2002) have argued and have found evidence for the existence of two distinct phases in the learning to read process. An initial phase is predominated by the perceptual analysis of textual features, and an advanced phase is predominated by syntactic analysis and meaning abstraction. Owing to the prevalence of perceptual feature analyses, initial reading is predominantly mediated by the right cerebral hemisphere, whereas the prevalence of syntactic and semantic analyses calls for predominant mediation of advanced reading by the left cerebral hemisphere. Evidence is available in support of the proposed hemispheric shift in the subservience to reading (Licht et al., 1988). As some children may not be able to make the hemispheric shift in time, they persist in the excessive generation of right hemispheric reading strategies, causing them to read in a slow and fragmented fashion as they did from the very onset of the learning to read process. This reading failure has been denoted P-type dyslexia (P for perceptual); others call these dyslexic readers "spellers" (Van der Schoot, Licht, Horsley, & Sergeant, 2000, 2002). Some other children may try to use lingual strategies generated by the left hemisphere too early, causing them to read fast and inaccurately. This reading failure has been denoted L-type dyslexia (L for linguistic), or "guessers" (Van der Schoot et al., 2000, 2002). In distinguishing P- from L-type dyslexia, one usually has a group of dyslexic children read a piece of text, followed by a count of mistakes and seconds needed to complete the piece. The children who read relatively slowly and accurately are denoted P-dyslexic children whereas those who show the reverse pattern of performance (i.e., fast but inaccurate) are denoted L-type dyslexic children. Some investigators, notably in Italy (e.g., Fabbro et al., 2001) distinguish a third type, an M type, of dyslexia: dyslexic children who read both relatively slowly and inaccurately.

The results of several investigations evidence the validity of the P/L-classification of dyslexia (Fabbro et al., 2001; Facoetti, Lorusso, Paganoni, Umiltà, & Mascetti, 2003; Licht et al., 1988; Licht & Van Onna, 1995; Masutto, Bravar, & Fabbro, 1994; Van der Schoot et al., 2000, 2002; Van Strien, Bakker, Bouma, & Koops, 1990). Some of these studies revealed possible mechanisms underlying the P versus L distinction. Thus, Fabbro et al. (2001) found L- and M-types, but not P-types, to have difficulty with the interhemispheric exchange of tactile information presented to the fingers of the left and right hand. Facoetti et al. (2003) found that improvement of reading through appropriate hemisphere-specific stimulation in P-, L-, and M-dyslexic children, as shown by Lorusso, Facoetti, Paganoni, Pezzani and Molteni (in press), goes with improvement of focussed visual attention in these children. Van der Schoot et al. (2000, 2002) showed the importance of visual attention in the distinction of P- versus L-dyslexia, especially when it comes to the inhibition of an ongoing response to a visual stimulus. L-dyslexic children perform significantly worse in this respect than both P-type dyslexic and normally reading children.

L- and P-type dyslexic children have been treated successfully by stimulation of the right and left cerebral hemisphere, respectively (Bakker, Bouma, & Gardien, 1990; Bakker & Vinke, 1985; Bodien, 1996; Goldstein & Obrzut, 2001; Kappers, 1997; Lorusso et al., in press; Robertson, 2000a). Treatment effects, or effects of treatment by type of dyslexia, failed to show up in some other studies though (Dryer, Beale, & Lambert, 1999; Grace & Spreen, 1994). Dryer et al. (1999) showed a robust reading effect of hemisphere stimulation, but that effect was found to be nonspecific for hemisphere and type of dyslexia. Thus, it did not much matter whether the right or left hemisphere was stimulated in either P- or L-dyslexic children. Facoetti et al. (2003) and also Lorusso, Facoetti, and Molteni (2004), in considering the outcomes of their own studies and those of Dryer et al., have suggested that nonhemispheric factors such as attention, memory, and nature of the stimulus-material may play a role.

Neuropsychological versus control treatment of dyslexia in all these studies was accomplished by hemisphere-specific stimulation (HSS) through the presentation of words in one of the lateral planes (visual half-fields: HSSvisual; fingers of the hands: HSStactile), or by hemisphere-alluding stimulation (HAS). HAS provides for the presentation of perceptually demanding text (e.g., different typefaces within a word) to L-types, and for the presentation of phonetically and syntactically demanding text (e.g., finding words by using rhyme or context) to P-types. Perceptually (for L-types) and linguistically (for P-types) demanding texts are presumed to allude to predominant right and left hemispheric processing, respectively (see Bakker, 1990; Robertson, 2000b). The hemisphere-specific (HSS) and hemisphere-alluding (HAS) stimulation procedures, both for L- and P-dyslexic children, are outlined in figure 1. M-type dyslexic children usually receive right and left hemisphere stimulation in an alternating fashion.

In some of the treatment studies, both the HSS and HAS methods were applied, either within or between treatment sessions (e.g. Dryer et al., 1999; Goldstein & Obrzut, 2001; Robertson, 2000a).



A: *HSSvisual*; words flashed right of X (P-type dyslexia) or left of X (L-type dyslexia).
B: *HSStactile*; words presented to right or left hand in P- and L-dyslexia, respectively.
C: *HAS for L-type dyslexia*, text alluding to right hemisphere processing.
D: *HAS for P-type dyslexia*, rhyming words, alluding to left hemisphere processing.

Figure 1. Outline of HSS- (A: HSSvisual; B: HSStactile) and HAS- (C: for L-types; D: for P-types) treatments (C and D are from Kipling's Verse, 1927).

Bakker and Vinke (1985) had P- and L-dyslexic children experimentally treated, either by HSSvisual or HAS. HSSvisual provided for words flashed in the left visual field in a group of L-dyslexic children and in the right visual field in a group of P-dyslexic children. Control treatments for HSSvisual concerned words flashed in the central visual field in both a group of L-dyslexic and a group of P-dyslexic children. Two other experimentally treated groups received HAS (i.e., appropriate textual material prepared for a group of L- and a group of P-dyslexic children). To control for possible HAS effects, two other groups, one L and one P, both were presented textual material for L-dyslexia in the one session and textual material for P-dyslexia in the next session. Finally, a group of L-dyslexic children and a group of P-dyslexic children did not receive any treatment. Significant effects of HSSvisual and HAS on the quality of reading were reported. The experimental and control treatments used by Bakker and Vinke served as a paradigm in the present investigation.

The origin of the left hemisphere bias in L-type dyslexic children and the right hemisphere bias in P-types is not known. However, a right hemisphere bias facilitating early but not advanced reading or a left hemisphere bias that acts vice versa, may be apparent before the start of learning to read. Better visual-spatial performance, relative to verbal performance, is thought to reflect a right hemisphere bias whereas better verbal than visual-spatial performance is assumed to be indicative of a left hemisphere bias. This holds both for the quality of reading within the normal and the dyslexic range. Thus, children at risk for developing a reading problem, who demonstrate better visual-spatial than verbal capacity before reading onset, will ultimately appear to be less “retarded” in early reading than similar at-risk children who demonstrate better verbal than visual-spatial capacity. However, those of the latter group who do receive early right hemisphere stimulation will be less retarded in early reading than the children without such stimulation. Conversely, early left hemisphere stimulation in at-risk children who demonstrate visual-spatial proficiency will be disadvantaged in early reading. These predictions will be investigated in the present study.

It is difficult to formulate similar predictions with regard to advanced reading. In an early study (Bakker, 1979), it was found that normal children who demonstrated left ear advantage to a dichotic input of digits at kindergarten were better readers at Grade 5 than those who had demonstrated right ear advantage. In another sample, it was also found that children who shifted from left to right ear advantage in the period from kindergarten to primary Grade 2 ultimately were the best readers at Grade 6. Kappers (1987) reported similar findings. However, normal rather than at-risk children participated in these studies and hemispheric biases in the processing of verbal inputs were inferred from a dichotic listening task. At-risk children took part in the present study and lateral plane advantages were not investigated. This being the case, one does not know what happened with regard to (shifts) of hemispheric biases in the period from primary Grade 1 to Grade 5. As a consequence, reliable predictions as to the reading performance of the present at-risk children in Grade 5 are not possible.

METHOD

PARTICIPANTS

After having received permission by the authorities, the authors contacted all kindergarten schools of the district “Gelders Rivierengebied” in The Netherlands to request their cooperation in the project. The total number of first Grade kindergarten children in that district was 1,271. Of all 135 schools, 102 (76%) decided to participate. The main reason for refusing to participate in the project was the already high workload of the school management. Many meetings were held to explain—both to the inspectors, teachers, and parents—what the nature of the project was. The first step concerned requesting the teachers to indicate whether a child was felt by them to be “most likely, likely, doubtfully, unlikely, or most unlikely” to develop a reading problem. For doing so, the teachers were not given any hints. The number of children considered most likely or likely to be at risk was 193. From these, a number of children was not further available for the following reasons: children from foreign cultures and/or speakers of a language other than Dutch (n = 18), children whose parents refused further examination (n = 15), children whose parents moved to another country or to outside the school district (n = 4), children who moved to special education (n = 5), and children not available for various other reasons (n = 10). The final sample thus consisted of 141 year 1 kindergarten children (42 girls and 99 boys) with an average age of 5.1 years.

TESTS

The 141 at-risk children were administered the Dutch version of the Florida Kindergarten Screening Battery (FKSB-D) (Dekker &

Van der Vlugt, 1982; Satz & Fletcher, 1982). Because Dekker and Van der Vlugt (1982) had administered the FKSB-D to a large random sample of children who, on average, were one and a half-years older than the present at-risk children, it was decided to do a try-out with the test first. To that aim, the FKSB-D was administered to a small group of 48- to 53-month-old children from a kindergarten school outside the area where the at-risk children were located. These children appeared to be quite able to perform the tests, with one exception: with the subtest Recognition Discrimination, the children did not understand the term "exactly the same" in the instruction to indicate which figure is exactly the same as one of the figures at the top line. In view of this observation, it was decided to present a few exercises prior to administering the actual test. This Precursor Test (RD1) consisted of pictures of concrete objects such as ducks and fish, presented in one or another spatial position. The child had to indicate which one of the figures at the top exactly matched the picture of the object presented. It was also decided to relax the breaking-off rules of some subtests in order to prevent too much fatigue.

The following FKSB-D tests were administered to all the children in quiet rooms in the school.

Peabody Picture Vocabulary Test (PPVT) (Dunn & Dunn, 1981; Manschot & Bonnema, 1974). The test taps receptive word knowledge. The child indicates which one of four pictures fits a word spoken by the tester. The first three items serve as examples. Testing is stopped when the child makes six mistakes in eight consecutive items, and the score is the total number of items correct.

Word Knowledge (WK) (Dekker et al., 1982). The test taps expressive word knowledge. The child, by keeping his or her eyes closed, is required to say as many words as possible within a given category in one minute. The categories are "What can you eat?" "What can you play with?" "What can you see in school?" and "Which animals can you name?" The total correct score across these four categories represents the child's expressive word knowledge.

Auditory Analysis (AA) (Dekker & Van der Vlugt., 1982). The test measures auditory analysis of words. The child is required to repeat words spoken by the tester and to do this once again, but this time without a part of the word spoken. Degree of difficulty increases gradually; for instance, "teacup" without "tea" and later on "cup" without "p". Prior to the testing, examples are presented. Testing is stopped when the child fails in six subsequent items, and the total items correct form his or her score.

Developmental Test of Visual-Motor Integration (Beery VMI) (Beery & Buktenica, 1967, extended version). The test measures the integration of visual and motor performance. The child is required to copy 24 geometric figures, one by one and without using an eraser, while the target figure is visible all the time. The complexity of the figures increases gradually. The test is stopped after three wrong reproductions. The total number of items correct according to existing criteria forms the child's score, which can be transformed to an age-equivalent score in months.

Recognition-Discrimination (RD) (Small, 1969). The test measures visual discrimination performance. The child is required to indicate which one of four figures is exactly the same as the target figure at the top of the page. The four figures can be rotated or mirrored, or can be different in a detail. Three versions were used: RD1 (Glaudé, 1986), a simple version with pictures of objects as above; RD2 (Small, 1969), simple abstract figures for children; and RD3 (Small, 1969), complex abstract figures for older children and adults. Testing is stopped after four subsequent failures and RD3 is administered only in case four subsequent failures do not occur in RD2. The total number of items correct on RD2 and RD3 separately form the raw scores. In the present study, the RD2 and RD3 raw scores were combined for some analyses with a correction of five points because of some overlap in RD2 and RD3 scores.

Rapid Naming (RN) (Dekker & Van der Vlugt, 1982). The test measures the automaticity of associations between the photographs of objects and their meaning. The test consists of rows of pictures of common objects, in different order, which the child is required to name from left to right, and to do so as fast as possible. Prior to testing, it is checked to be sure that the child could name the objects. The total number correct forms the child's score.

Alphabet Reciting and Counting (AR-C) (Dekker & Van der Vlugt, 1982). The test measures the incidental learning of series. The child is required to say the alphabet and thereafter to count for one and a half minutes, starting with digit one. The total number of items correct on the alphabet and on counting forms the child's score. The total number of letters spoken in the correct order and the number of digits per 30 seconds provide the other scores.

In a separate study (Glaudé, 2003), the results of the 141 at-risk children on the FKSB-D were compared with the results of

49 children on the same test battery. The latter children had been randomly selected from a pool of six separate schools, located outside the pool of schools from which the at-risk children had been recruited. These "normal" children were found to perform significantly better than the at-risk children on all the subtests of the FKSB-D, Alphabet Reciting being the exception. The FKSB, according to Satz and Fletcher (1982), shows high validity in the prediction of severely disturbed through efficient reading.

DATA REDUCTION

In order to reduce the number of test variables, aiming to create more meaningful constructs and to facilitate the intended subtyping of the at-risk children, a principal components analysis followed by varimax rotation was performed. Similar to Satz and Fletcher (1982), Dekker (1983) and Dekker and Van der Vlugt (1982) decided to use raw scores only (numbers correct and time scores). Number Counting rather than Alphabet Reciting was included as a variable, as the first did and the second did not discriminate between at-risk and normal children in studies by Dekker (1983) and Glaudé (2003). With regard to Rapid Naming, the speed score rather than number correct was selected for inclusion in the analysis. Almost all children appeared to be able to name all the pictures although the speed in doing so was quite different. Means, standard deviations, and intercorrelation coefficients of the tests included in the principal component analysis are rendered in table I.

The results of the component analysis are summarized in table II.

The interpretation of the various outcomes compels some caution as the intercorrelation between and the communalities of some tests are rather low. The first two components found together count for 60% of the variance. It mainly is the visual-spatial test scores, notably those on Recognition Discrimination and Beery Visual-Motor, which load on component 1; this component may thus be named "visual-spatial." Counting also loads highly on component 1. The scores on the verbal tests Peabody Picture Vocabulary and Word Knowledge load on component 2; this component may thus be named "verbal." Unexpected is the loading of Beery Visual-Motor on component 2. It is hard to find an explanation for the findings that Counting loads on the "visual-spatial" component and that Beery Visual-Motor loads on both components. One possibility is that more than one strategy can be used to solve a task, and

Table I. Means, standard deviations, and intercorrelations of tests

Tests	Means & Standard Deviations	Peabody Picture Vocabulary	Beery Visual-Motor	Rapid Naming	Word Knowledge	Recognition Discrimination	Auditory Analysis
Peabody Picture Vocabulary	42.57(10.18)						
Beery Visual-Motor	6.19 (2.81)	0.53					
Rapid Naming	50.74 (19.01)	-0.13	-0.28				
Word Knowledge	21.06 (7.70)	0.47	0.44	-0.22			
Recognition-Discrimination	13.56 (8.93)	0.37	0.61	-0.31	0.35		
Auditory Analysis	4.28 (4.53)	0.41	0.42	-0.07	0.29	0.41	
Counting	20.38 (12.17)	0.29	0.48	-0.17	0.29	0.51	0.38

Table II. Component Loadings of the Florida Kindergarten Screening Battery—Dutch Version (FKSB-D) scores

Tests	Component 1	Component 2	h^2
Recognition-Discrimination	0.78	0.26	0.68
Beery Visual-Motor Integration	0.63	0.49	0.63
Auditory Analysis	0.38	0.40	0.30
Peabody Picture Vocabulary	0.18	0.86	0.77
Word Knowledge	0.32	0.48	0.33
Rapid Naming	-0.33	-0.10	0.12
Counting	0.58	0.24	0.39
Eigenvalues	3.22	0.98	
Percent variance explained	46	14	60

that the one strategy, rather than another one, becomes dominant during development. In Counting, for instance, a young child may count on the basis of a visual image of the digit pictures that are almost presented daily in their kindergarten schools. Possibly a young at-risk child is not yet able to abstract counting from picture and finger naming, whereas a number of normal children may already be able to do so.

SUBTYPING

The aim of the present investigation is to detect at-risk children who may develop an L- or P-type of dyslexia at the time they actually learn to read. The assumption is that an L-type of dyslexia may develop in those at-risk children who show relatively poor perceptual skills (Latent L-type: LAL) and that relatively poor verbal skills are a precursor to a P-type of dyslexia (Latent P-type: LAP). Licht and Van Onna (1995), while investigating children with manifest dyslexia, did show that L- and P-dyslexic children performed best on basic lingual and visual tasks respectively.

In order to reveal LAL- and LAP-children, two separate discriminant function analyses were performed; one with tests that loaded highest on the visual-spatial component in the principal component analysis and the other with tests that loaded highly on the verbal component. Recognition Discrimination and Beery Visual-Motor were selected as visual-spatial tests (raw scores) whereas Peabody Picture Vocabulary and Word Knowledge (raw scores) were selected as verbal tests. Auditory Analysis and Rapid Naming were not selected in view of their relatively low loading on either component. Counting was omitted because the loading of this test on the visual-spatial component was felt puzzling.

Classified as LAL-children were those who scored below the discriminant value in the analysis of the visual-spatial component, and classified as LAP-participants were those who did similarly in the analysis of the verbal component. As a result, 23 children could be grouped as LAL and 27 children as LAP. All together, these are not very many children, considering our goal to study the effects of early intervention in these at-risk children. To do intervention with four treatment conditions for each of LAL- and LAP-children would imply that only some five or six children were available in each of the treatment conditions, while 10 participants in each condition were preferable. To enhance the number of LAL- and LAP-children, partial component scores were obtained using the previous mentioned component analysis, such that only Peabody Picture Vocabulary, Word Knowledge (verbal component), Recognition Discrimination, and Beery Visual-Motor (visual-spatial component) were entered in the analysis. Partial component scores were calculated by multiplying the standardized scores of the test variables, with the component coefficients emerging from the principal component analysis. Thus, the partial component score for the verbal component was found to be (.799 x Z-score Peabody Picture Vocabulary) + (.100 x Z-score Word Knowledge), and the one for the visual-spatial component (.288 x Z-score Beery Visual-Motor) + (.558 x Z-score Recognition Discrimination). At-risk children who performed relatively better on the verbal tests than on the visual-spatial tests were considered LAL-subjects (n = 22) and those showing the reverse pattern were considered LAP-subjects (n = 14). Adding up the earlier numbers, 45 (23 + 22) children were classified as LAL and 41 (27 + 14) as LAP. Electrophysiological data (Glaudé, 2003) evidenced the LAP- and LAL-children to represent different groups of at-risk children.

INTERVENTION

TYPES OF INTERVENTION

Intervention in LAL- and LAP-children was provided at the end of kindergarten, year 2 (10 weekly sessions), and at the beginning of primary school, Grade 1 (five weekly sessions). Each session lasted for approximately 45 minutes. In a preintervention phase, the children were taught to read a number of words using a reading method for very young children entitled "De Leeshoek," ("Reading Corner") (Hoek & Oosterhuis-Hoogland, 1987). Target words like "fish," "cage," and "box" came in short sentences. The ultimate aim was to help the children to be able to read single target words printed on cards. This was necessary as these target words were used during intervention. For details of the preintervention procedure, readers are referred to Glaudé (2003).

Within the LAL-group and also within the LAP-group, four types of intervention were created:

1. LAL-HSS and LAP-HSS received hemisphere-specific stimulation, LAL-HSS by flashing words in the left visual field (in order to stimulate the right hemisphere) and LAP-HSS by flashing words in the right visual field (in order to stimulate the left hemisphere).
2. LAL-BIS and LAP-BIS received bilateral stimulation by flashing words in the central visual field (in order to stimulate both hemispheres).
3. LAL-HAS and LAP-HAS received hemisphere-alluding stimulation, LAL-HAS by having the children read perceptually laden text (alluding to right hemisphere processing) and LAP-HAS by having the children read text with rhyme words (alluding to left hemisphere processing).
4. LAL-NIN and LAP-NIN did not receive any intervention; the children stayed in the classroom at the time all the other children did receive some type of intervention.

These types of intervention were in accordance with the types of treatment used by Bakker and Vinke (1985) for the assistance of primary school children with manifest dyslexia. The children were pseudo-randomly allocated to an intervention group. Random allocation could result in some children from a particular school receiving intervention and some others being devoid of intervention; this was felt to be undesirable. Rather, schools were randomly selected where HSS or BIS and those where HAS or NIN would take place. The type of treatment children within schools would receive was decided randomly.

For HSS, an early experimental version of the computer program "HEMSTIM" (Moerland & Bakker, 1993) was used. Using a joystick, a child had to direct a randomly moving cursor (a +

shape) toward a small square at the center of a screen (point of fixation). Fusion of cursor and square triggered the flashing of a word at the left (for the LAL- HSS-children in order to stimulate the right cerebral hemisphere) or the right (for LAP- HSS-children in order to stimulate the left cerebral hemisphere) of the center of the screen. The fusion procedure aims to ensure fixation at the very moment a word is flashed in the left or right visual field. The words came at an angle of 2.5 to 5 degrees in either case. The words that were flashed were the ones mastered during the preintervention period. The child was required to say the flashed word aloud. Flashing time, 300 msec at the beginning, usually decreased over sessions. LAP- HSS-children received the words in lower typeface, as used in preintervention training. The same held true for the LAL- HSS-children, except that the letters were perceptually complex—for example, by using "Old-English" typefaces—in an effort to create an extra appeal on right hemispheric processing (see Bakker & Vinke, 1985).

The BIS-intervention was the same as the HSS-intervention with the exception that the words were flashed in the central visual field; that is, at the point of fixation in the center of the screen. In an effort to further counterbalance right versus left hemispheric involvement in word processing, the LAP- BIS-children occasionally were asked to give a word to rhyme with the one flashed, and the LAL-BIS-children occasionally were presented two words, which as they had to tell, were the same or different (see Bakker & Vinke, 1985). BIS was meant as a control for HSS as it was felt that solely training with a computer could cause reading effects.

The HAS-procedure was somewhat laborious as most of its content had to be devised by the experimenter. Indeed, the words learned during the preintervention period were used, but in order to let these words alluding to predominant left or right hemispheric processing some provisions had to be made. For LAL-HAS-children, the words were perceptually demanding in that the type faces with shadows came in the form of blocks or in three-dimensional print. The words could go with pictures and colors. It was demanding for the child to become aware of the letters that were enclosed in the perceptual configuration. LAP-HAS-children, on the other hand, had to read the words as printed in the preintervention periods. For them, there were no pictures and no colors; rather, they were asked to find rhyming words to the one presented, opposite words, or the category of objects categorizing the word. Evidence is available to show that perceptually laden letters, different from conventionally printed ones, allude to right rather than left hemispheric processing (Faglioni, Scotti, & Spinnler, 1969). HAS has been used in a number of clinical investigations with primary school children with dyslexia (Bodien, 1996; Kappers, 1997; Robertson, 2000a).

READING TESTS

The reading level of the children was investigated at the beginning and the end of the primary school period (Grade 1 and Grade 5/6). Standardized and widely used word and text reading tests were administered: The Eén-Minuut-Test (EMT, "One-Minute-Test") (Brus & Voeten, 1973, Version A) and the AVI ("AVI-Text Reading") (Van de Berg & Te Lintelo, 1977, Version A).

The EMT requires the child to read unconnected words of increasing difficulty as quickly and as accurately as possible, and to do so for one minute. The number correct is the raw score, which according to standard norms, can be transformed to an age-level in months. As normal age levels are available, backwardness or forwardness in reading (in months) can be established: normal age level minus the child's age level. The AVI requires the child to read connected text. Standard AVI levels are available for each Grade. Having mastered a standard Grade level means that a child is able to read the text according to the speed and accuracy values set for that level. If a child performs better than the standard grade level, he or she is administered a higher AVI level. The mastery of each AVI level equals a reading-age in months. Thus, backwardness or forwardness in text reading (in months) can be established: normal age level minus the child's reading age.

About half of the children had moved from the kindergarten school directly to a primary school or a school for special education; these "movers" were tested when they had arrived at the end of Grade 1 and Grade 5/6. Some other children had repeated the second year of kindergarten; these "stayers" also were tested at the end of Grade 1 primary school (a year later than the "movers"). "Stayers" and "movers" were about equally divided over the intervention groups, as were the types of school within the group of "movers."

PREDICTIONS

The previously described types of intervention in LAL- and LAP-children are outlined in table III.

Table III. Types of Intervention in LAL- and LAP-Children

Group	Type of Intervention	Through
LAL-HSS	Specific stimulation of right hemisphere	Flashing words in the left visual field
LAL-BIS	Stimulation of both hemispheres	Flashing words in the central visual field
LAL-HAS	Alluding stimulation of right hemisphere	Presenting perceptually laden text
LAL-NIN	No intervention	Children stay in classroom
LAP-HSS	Specific stimulation of left hemisphere	Flashing words in the right visual field
LAP-BIS	Stimulation of both hemispheres	Flashing words in the central visual field
LAP-HAS	Alluding stimulation of left hemisphere	Presenting phonemically laden text
LAP-NIN	No intervention	Children stay in classroom

It was predicted that:

1. At-risk children, both LAL- and LAP-typed, show reading backwardness across types of intervention.
2. Degree of backwardness depends on type of intervention: nonintervened LAP-children (LAP-NIN) and LAL-children who received stimulation of the right hemisphere (LAL-HSS and LAL-HAS) are not backward in early reading.

Backwardness was investigated within and between types of intervention. It is recognized that children found "backward in reading" does not necessarily means that these children should be denoted "dyslexic." After the testing of reading performance, it became evident that the scores were quite diverse. In order to minimize the influence of outliers, it was decided to use nonparametric statistics for the analyses of the data.

RESULTS

GRADE 1

Wilcoxon Signed Rank Test revealed the at-risk children to be significantly backward in both word reading ($z = 4.05$, $p < .001$)

and text reading (z = 6.80, $p < .001$). These results were obtained across intervention groups. Degree of backwardness in LAL- and LAP-children appeared not to differ significantly, neither for word reading (z = .462, p = .64) nor for text reading (z = .288, p = .77). Mean degrees of backwardness, by type of risk and type of intervention, are depicted in figure 2.

As to *word* reading, Wilcoxon Signed Rank Test revealed significant degrees of backwardness in LAL-HSS (z = 2.12, p = .034), LAL-NIN (z = 2.53, p = .011), and in LAP-HSS (z = 2.67, p = .008). Degree of backwardness was not significant within the other groups (LAL-BIS: z = .60, p = .550; LAL-HAS: z = .56, p = .573; LAP-BIS: z = .99, p = .324; LAP-HAS: z = 1.37, p = .172; LAP-NIN: z = 1.54, p = .123). Comparisons between groups (Kruskal-Wallis Test) failed to reveal significant differences (p values > .05).

With regard to *text* reading, within group analyses (Wilcoxon Signed Rank Test) revealed significant degrees of backwardness in all groups (LAL-HSS: z = 2.23, p = .026; LAL-BIS: z = 2.23, p = .026; LAL-HAS: z = 2.59, p = .010; LAL-NIN: z = 2.69, p = .007; LAP-HSS: z = 2.82, p = .005; LAP-BIS: z = 2.23, p = .026; LAP-HAS: z = 2.39, p = .017; LAP-NIN: z = 2.56, p = .011).

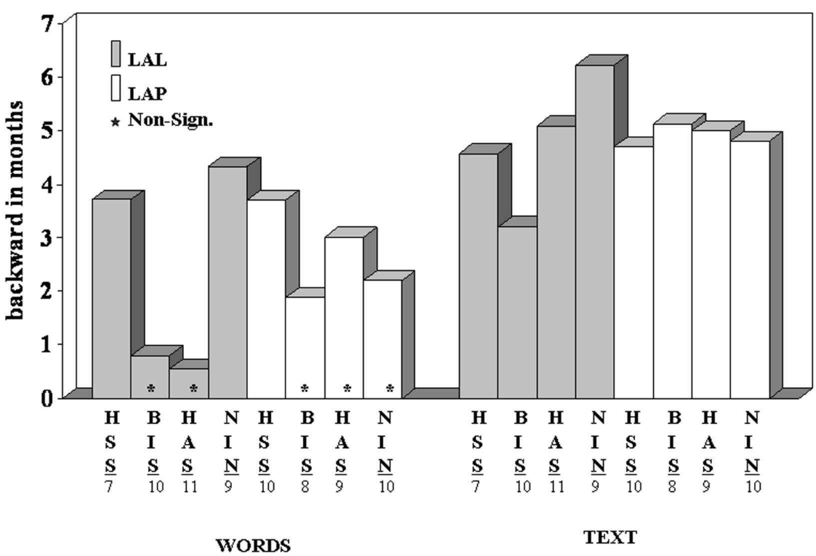


Figure 2. Primary school Grade 1: mean backwardness (months) in word and text reading by type of risk (LAL & LAP) and type of treatment (HSS, BIS, HAS, & NIN; numbers indicate number of participants in each treatment group).

Comparisons between groups (Kruskal-Wallis Test) did not reveal significant differences (p values > .05).

GRADE 5/6

At Grade 5/6, cell frequencies were smaller than at Grade 1 as a number of children was lost over the years (see Follow-up Sample). Overall, the children at risk showed significant degrees of backwardness in both word reading ($z = 6.13$, $p = .000$) and text reading ($z = 4.60$, $p = .000$). Degree of backwardness in LAL- and LAP-children was not found to differ significantly, neither for word reading ($z = .085$, $p = .93$) nor for text reading ($z = .796$, $p = .43$). Mean degrees of backwardness in word and text reading, by type of risk and type of intervention, are depicted in figure 3.

Statistical analyses within groups revealed significant degrees of backwardness in *word* reading in groups LAL-BIS ($z = 2.37$, $p = .018$), LAL-NIN ($z = 2.80$, $p = .005$), LAP-HSS ($z = 2.67$, $p = .008$), LAP-HAS ($z = 2.19$, $p = .028$), and LAP-NIN ($z = 2.55$, $p = .011$). No significant backwardness was found in groups LAL-HSS ($z = 1.60$, $p = .110$), LAL-HAS ($z = 1.70$, $p = .09$), and LAP-BIS ($z = 1.37$, $p = .17$). Between-group analysis (Kruskal-Wallis) failed to show significance (p values > .05).

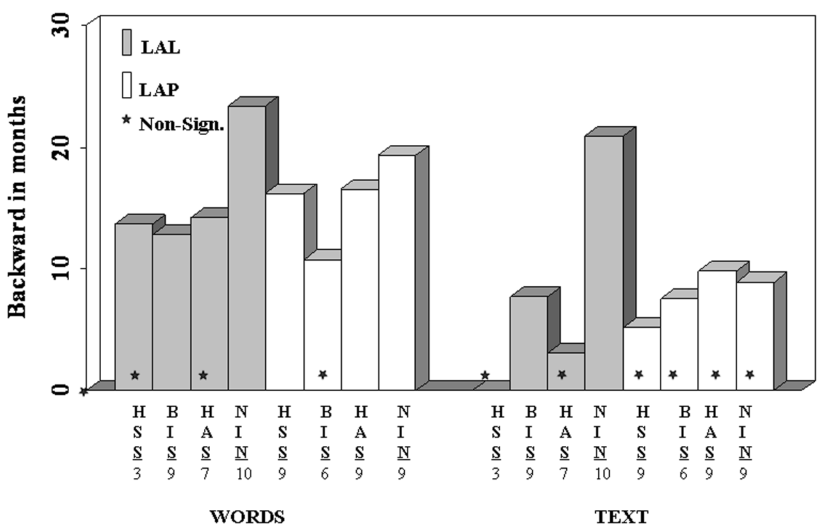


Figure 3. Primary school Grade 5/6: mean backwardness (months) in word and text reading by type of risk (LAL & LAP) and type of treatment (HSS, BIS, HAS, & NIN; numbers indicate number of participants in each treatment group).

As to *text* reading, within-group analyses showed LAL-BIS ($z = 1.90$, $p = .06$) and LAL-NIN ($z = 2.81$, $p = .005$) children to be (nearly) significantly backward. The other groups were not: LAL-HSS ($z = 0.00$, $p = 1.00$), LAL-HAS ($z = 0.18$, $p = .85$), LAP-HSS ($z = 1.36$, $p = .18$), LAP-BIS ($z = 1.38$, $p = .17$), LAP-HAS ($z = 1.55$, $p = .12$), and LAP-NIN ($z = 1.75$, $p = .08$). A between-group analysis (Kruskal-Wallis) revealed the degree of backwardness to differ between LAL-groups ($\chi^2 = 11.49$, df = 3, $p = .009$), indicating that each LAL-HSS ($z = 2.56$, $p = .011$) and LAL-HAS ($z = 2.50$, $p = .012$) showed less backwardness than LAL-NIN.

FOLLOW-UP SAMPLE

As mentioned, fewer children were available for examination in Grade 5/6 than were available in Grade 1: 12 of the 74 children dropped out, leaving 62 children in Grade 5/6. Most of these stayed in regular primary schools; 14 of them stayed in special schools. The latter were about equally divided over the treatment groups. Although the 62 follow-up children of Grade 5/6 concern a large subsample of the original 74 children in Grade 1, it may be worthwhile to investigate the performance of this follow-up group in Grade 1. The results of this follow-up group and those of the original group may deviate as reading performance of the 12 dropouts was found to be lower than the reading performance of the 62 follow-up children, albeit not significantly so (p values > .05; 2-tailed).

In analyzing the results of the follow-up children in Grade 1, for LAL-children, it appeared that similar to the original sample, LAL-BIS and LAL-HAS did not reach significant backwardness in word reading (p values > .05). However, different from the original sample, LAL-HSS did not reach significant backwardness in word reading, nor did LAL-BIS in text reading (p values > .05).

As to the LAP-children, it was found that similar to the original sample, backwardness in word reading did not reach significance in LAP-BIS, LAP-HAS, and LAP-NIN (p values > .05), but did in LAP-HSS ($z = 2.53$, $p = .012$). All LAP-groups, as in the original sample, were found significantly backward in text reading (p values < .05). Between-groups analyses (Kruskal-Wallis) did not reveal significance (p values > .05), neither with regard to word reading nor with regard to text reading.

In conclusion, the overlap of treatment effects in the follow-up sample and the original sample is substantial in spite of the fact that the latter sample includes a number of the poorest readers. That being the case, the results at best suggest that specific stimulation of the right hemisphere may have some beneficial effect on the early word reading of LAL-children who are not the worst of all poor readers (see effect of LAL-HSS in the follow-up versus the original sample), and that bilateral stimulation in them (LAL-BIS) may be beneficial to early text reading.

TEACHERS' EVALUATION

The teachers of Grade 5/6 were asked to give their opinion about a child's level and quality of reading (a few of the 62 children could not be evaluated by the teachers). The teachers were requested to fill out a form with yes or no items (e.g., is the child, according to your opinion, dyslexic or not), and items asking whether a child performs below, at, or above age norms of reading readiness, word reading, and text reading. The evaluations regarding the latter three reading domains correlated significantly (p values < .001). Figure 4 shows the percentage of children in each group who received at least one unfavorable evaluation regarding the reading domains (backwardness); the percentage of children considered dyslexic is also presented.

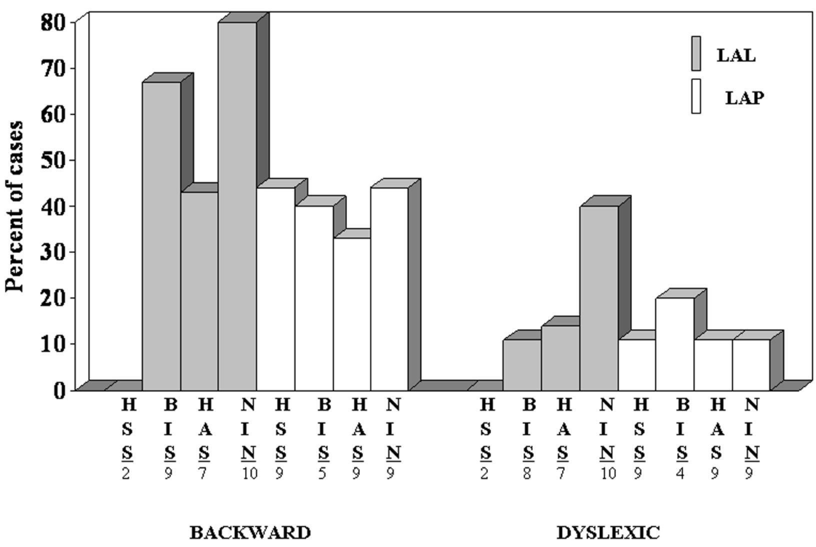


Figure 4. Percent of children by type of risk (LAL & LAP) and type of treatment (HSS, BIS, HAS, & NIN), who in Grade 5/6, according to their teachers, are backward in reading and/or dyslexic (numbers indicate number of participants in each treatment group; numbers may differ as a few children are not reported on).

The teachers considered 50% of the children backward in at least one of the reading domains and 17% to be dyslexic. No differences between LAL- and LAP-children were found in these respects (p values > .05). Of the children considered backward in reading, 27 % concern nonintervened LAL-children (LAL-NIN) and 40% of those considered dyslexic belong to LAL-NIN. The latter percentage is nearly significantly higher than the percentages reported for all other treatment groups (Fisher Exact Probability Test: $p = .058$).

CONCLUSION

In accordance with the prediction, children considered at risk by kindergarten teachers were shown to be backward in word and text reading, both at the start and at the end of primary school. Not all groups were backward though. LAL-HSS and LAL-HAS, both aiming to stimulate the right cerebral hemisphere of LAL-typed at-risk children, were found to be effective treatments for older subjects. First, these treatments produced nonsignificant degrees of backwardness in late word and text reading, and second, these treatments were found to go with less backwardness in late text reading than was found in nonintervened LAL-children (LAL-NIN). Early in the primary school, LAL-HAS, LAL-BIS, and LAL-HSS (in the follow-up sample only) failed to produce significant backwardness in the word reading of L-typed at-risk children. Across Grades, significant degrees of backwardness in both word and text reading were found in nonintervened LAL-children (LAL-NIN). The text reading of young LAL-typed at-risk children seems not affected by any treatment (except for LAL-BIS in the follow-up sample). In conclusion, stimulation of the right hemisphere in young LAL-typed at-risk children seems most effective, especially in view of their word and text reading at older ages.

No intervention (LAP-NIN) seems a good choice for LAP-typed risk children regarding the nonsignificant degrees of backwardness in early word and late text reading. However, similar nonsignificant effects showed up for LAP-HAS, LAP-BIS, and regarding advanced text reading, for LAP-HSS. Between-treatment differences were not found, neither for young nor for older LAP-children, and neither for word nor for text reading. As was the case with LAL-children, early text reading of LAP-children appeared unaffected by any treatment. In conclusion, treatment or no treatment, it seems not to make much of a difference for LAP-typed at-risk children. The pattern of performance on the reading tests is, by and large, reflected in the evaluation by the teachers, especially when the poor status of the nonintervened LAL-children is considered (see figure 4).

GENERAL DISCUSSION

This follow-up investigation aimed to trace the impact of predominant verbal or visual-spatial capacity of at-risk children in kindergarten on the quality of reading in early and late primary school. As a first step, all Grade-1 kindergarten children of a school district were considered by their teachers to be or not to be at risk for developing reading/writing/language problems in the future. The children who were designated as being at risk were administered the Florida Kindergarten Screening Battery. Those who performed better verbally than visual-spatially were classified as latent L-type (LAL) at-risk children. Those who performed better visual-spatially than verbally were classified as latent P-type (LAP) at-risk children. At the time the children were still in kindergarten, they did or did not (LAL-NIN and LAP-NIN) receive intervention. Types of intervention were similar to the treatment procedures used for children with manifest dyslexia (Bakker & Vinke, 1985). Thus, LAL-children received stimulation of the right cerebral hemisphere (LAL-HSS and LAL-HAS); the LAP-children of the left cerebral hemisphere (LAP-HSS and LAP-HAS). One LAL-group and also one LAP-group received bilateral stimulation (LAL-BIS and LAP-BIS). Word and text reading were examined in Grade1 and in Grade 5/6 of the primary school. Finally, the teachers of Grade 5/6 were asked to evaluate the level and status of their children's reading.

As expected, the estimates of the original kindergarten teachers turned out to be good predictors. In general, the at-risk children were found significantly backward in word and text reading, both at the beginning and at the end of primary school. This finding is in accordance with the outcome of other studies (Kappers, 1989; Satz & Fletcher, 1988). It was also expected that no intervention in LAP-children and right hemisphere stimulation in LAL-children are beneficial to early reading. This hypothesis appeared to hold for early word reading only. Apart from that, BIS- and HAS-intervention in LAP-children seems no more beneficial to early word reading as is no intervention (LAP-NIN). No prediction could be formulated with regard to late reading. It now appears that most benefit of intervention shows up at that phase. Whereas nonintervened LAL-children were found backward in late word and text reading, right-hemisphere stimulated LAL-children were not. The pattern found in LAL-children is not mirrored in LAP-children: nonintervened LAP-children did not show significant backwardness in late text reading but neither did LAP-children who had received any type of intervention. Only bilateral stimulation (BIS) appeared to affect late word reading in LAP-children.

Based on these outcomes, one would recommend to give LAL-type at-risk children right hemisphere stimulation as early as possible. Any firm advice would be premature for LAP-children, as almost all treatments seem no better than no treatment. The lowest degree of backwardness in early and late word reading though was obtained in LAP-children who had received bilateral stimulation (BIS), but that effect did not differ significantly from effects of any other treatment used for LAP-children. As bilateral stimulation also had a positive effect on early word reading in LAL-children, it may be worthwhile to further investigate the role of bilateral hemispheric stimulation on word reading in at-risk children.

An ultimate goal of primary school education is having children who read texts fluently and accurately. Overall, that goal was not attained in the present at-risk children. Yet it was late text reading that showed the most clear-cut effects of early intervention in that LAL-children having received stimulation of the right hemisphere perform significantly better than non-treated LAL-children. Backwardness in late text reading is absent in LAP-children, whether treated or not. Thus, it seems that having or creating an early bias for right hemispheric word processing is to the advantage of text reading at the conclusion of the primary school period.

At this point, one might wonder which mechanisms mediate the right hemisphere effect and whether such mechanisms are confined to right hemisphere activities. The latter question is pertinent in view of the finding that bilateral stimulation appeared effective, certainly so in LAP-children.

One possibility is that enhancement of temporal processing plays a role. Both in unilateral and bilateral stimulation, the procedure was that word flashing times decreased over intervention sessions. Thus, words had to be processed faster and faster in the long run. Given the results of research by Tallal and associates (e.g., Tallal et al., 1996), one would expect reading to improve. It is of interest in this respect that LAP-children especially appeared to be affected by bilateral stimulation (LAP-BIS) in that neither early and late word reading nor late text reading was found backward in them. These children read relatively slowly, in a fragmented fashion. In that case, one would expect the greatest effect of temporal speed increments in these children. At this junction, it may be worthwhile to consider the finding that HAS did and HSS did not reduce backwardness in the early word reading of LAP-children. In LAL-children, a similar HAS- versus HSS-effect showed up for early word reading, albeit in the original sample only. HAS allows for much slower information processing than HSS. As all novice reading proceeds slowly, one could imagine that the slow HAS-procedure, rather than the fast HSS-procedure, is effective in an early phase of the learning to read process. Whatever the role of the speed factor may be, probably it is not the only factor of importance to improve reading. The fact only that hemisphere-alluding stimulation (HAS) has demonstrated effectiveness in the treatment of dyslexia, and considering that enhancing the speed of temporal processing is not in HAS, the exclusive role of this factor is precluded.

Another reading facilitating factor that recently drew quite some interest is visual attention, especially response inhibition. First, Van der Schoot and coworkers (Van der Schoot et al., 2000, 2002), in a series of investigations, found L-type dyslexic children, different from P-type dyslexic and normally reading children, lack proficient inhibition during visual perception. Second, Lorusso and colleagues (Lorusso et al., in press) demonstrated P- and L-dyslexic children improve reading after HSS. Third, and most important, Facoetti et al. (2003) showed that those children, who in the Lorusso-study had improved in reading, also showed significant post- versus preintervention improvement in visual attention and inhibition. Many years ago, Morris (1989; see also Bakker, 1995) predicted that the focusing of attention may play a crucial role in the reading effects of hemisphere-specific stimulation. Treatment-induced changes in visual attention, notably the facilitation of inhibitory processes, may underlie improvement in reading through stimulation of a single hemisphere. Would it make any difference which hemisphere? Some evidence is available to show that stimulating either hemisphere at a time would do, at least in M-type dyslexic children (i.e., in children who show both the L- and P-style [inaccurate and slow] of reading) (Lorusso, Facoetti, & Molteni, 2004). Unfortunately, we are not able to present any suggestion in this issue as in the present research that either the right (LAL-HSS and LAL-HAS) or the left (LAP-HSS and LAP-HAS) hemisphere was stimulated. Thus, we are not in the position to tell what would have happened if the left hemisphere, rather than the right one, had been stimulated in LAL-children. Neither can we tell what right hemisphere stimulation in LAP-children would produce in terms of reading performance. Thus, whether facilitation of inhibitory processes underlies the reading effects of single hemisphere stimulation remains an open question.

In matching LAP-type at-risk children with P-type dyslexics and LAL-type at-risk children with L-type dyslexics, one may wonder whether such matching was substantiated in the present investigation. In other words, did the LAP- and LAL-children develop a P- and L-style of reading, respectively? This question is hard to answer, as most groups received intervention before the onset of the learning to read process. Thus, a developing P- or L-style of reading possibly was challenged by the intervention. Glaudé (2003) compared the reading of LAP-children who did not receive intervention and those LAL-children who received stimulation of the right hemisphere with the reading of LAL-children who did not receive intervention and those LAP-children whose left hemisphere was stimulated. This is comparing children having a (presumed) right hemisphere bias with children having a (presumed) left hemisphere bias in processing text. Glaudé had measures of reading speed and accuracy available. She only found a nonsignificant trend ($\chi^2 = 9.88$, df = 5, $p = .079$) for speed of text reading in Grade 5/6, the children with a right hemisphere-bias reading slower than the children with a left hemisphere bias. One of the criteria for P- versus L-classification is speed of reading (P-types being slower than L-types); the other one is accuracy (P-types being more accurate than L-types). Thus, Glaudé found that only the first criterion tended to differentiate between groups. Clearly, no firm conclusion can be drawn as to the LAP to P and the LAL to L transition with regard to the development of a reading style.

A different question arises from the finding that hemisphere stimulation in LAL- and LAP-children affected early word reading rather than early text reading. One may argue that reading words and the letters that constitute words are the first challenge for the novice reader and that an effect of intervention, if any, will, therefore, show up in early word reading to carry over into text reading only later on.

Summarizing the outcomes of the present investigation, the cautious conclusion seems warranted that it makes sense to subtype kindergarten children at risk of reading problems into latent L (LAL) and latent P (LAP), and to provide the first type with stimulation of the right cerebral hemisphere. As untreated LAP-children produced similar results as treated LAP-children, it remains to be investigated what the best treatment of LAP-typed at-risk children, if any, might be. It is interesting to note that LAL-typed at-risk children are the best responders to intervention. In children with a manifest L-type or P-type of dyslexia similarly, it is sometimes found that L-types are more proned to treatment than are P-types (Bakker et al., 1990; Bakker & Vinke, 1985). Why such is the case is presently unknown. P-types are relatively accurate but slow readers. Methods that enhance the speed of information processing may do best. Enhancement of processing speed was built into two of the treatment modes used in the present research (HSS and BIS). Effects of these treatments were observed but these effects evidently were not large enough to distinguish the treated LAP-children from the nontreated LAP-children. Research by Kappers (1997) suggests that treatment lasting longer than the 15 sessions of the present investigation may produce better results.

The conclusion seems warranted that right hemisphere stimulation in LAL-typed prereading at-risk children is most profitable to word and text reading in the long run. As to late text reading, the children treated with HSS and HAS not only showed absence of backwardness, but also showed better outcomes than the nontreated children.

The interpretation of the findings requires some caution though. First, two treatment groups had very few participants: LAL-HSS in late word and text reading. Nonetheless, this group did better than LAL-NIN. In considering this fact, one should also realize that the present findings do not stand alone. Bakker (1979) found that children who presumably showed a right hemisphere bias at an early age ultimately turned out to be the best readers of text. Second, one may ask the question as to how far the results can be generalized to language domains different from the Dutch language. Dutch is a Germanic language, like German and the Scandinavian languages. It will be clear that only replication studies can reveal the possible effects of different tongues. Hemisphere-specific (HSS) and hemisphere-alluding (HAS) stimulation for the treatment of manifest dyslexia has been used within a number of language domains and with positive outcomes in general (for an overview see Bakker, in press). To date, however, these interventions have not been used in kindergarten children who are differentially at risk of developing dyslexia.

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Address correspondence to: Dirk J.Bakker: dj.bakker@ext.vu.nl

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